Race/ethnic differences in the association of education and mortality

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Abstract:

Background: While the education-mortality gradient is well established among US adults, less is known about how it varies by race/ethnicity especially for understudied races such as Asians and Native Americans.

Proposed Methods: Data from the U.S. National Longitudinal Mortality Study (NLMS). Survival models for adults age 25 and older (n=725,373) with race by educational interaction terms are used to test multiplicative interaction; additional procedures test for additive interaction.

Preliminary Results: Educational gradients in mortality do not differ significantly across race/ethnic groups on the multiplicative scale. However, preliminary analyses suggest that additive interactions may be significant for at least some race/ethnic groups and at least some education levels.

Preliminary Conclusion: Previous mortality studies that have explored the joint effects of demographic factors have assessed interaction solely on the multiplicative scale. We will discuss the importance of both interaction perspectives in terms of methodology and especially in terms of substantive interpretations and policy relevance.

Keywords: Race, ethnicity, health, mortality, education

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Ethical approval: This article does not contain any studies with human participants or animals performed by any of the authors.

Introduction

The association of higher educational attainment with longer life expectancy has been observed in a variety of settings [1-4]. Link and Phelan's Fundamental Cause Theory (FCT) [5] asserts that the socioeconomic gradient in health and mortality will persist even as the causal mechanisms change, as those with higher socioeconomic status (SES) are better able to leverage money, prestige, knowledge, and other attributes to protect their well-being. Health differences by other demographic characteristics, such as race/ethnicity, were not fully discussed in the initial conception of FCT [5]. However, race/ethnicity is strongly correlated with SES, and in a later paper, Link and Phelan note that "it is possible that other social statuses, such as race, ethnicity, or gender, also have enduring associations with resources of money, knowledge, power, prestige, and beneficial social connections, and with health and mortality, and that they may also operate as fundamental causes. Race and ethnicity are strongly related to resources and consequently would be expected to behave similarly to SES [6]. Demographic characteristics may act as effect modifiers in the association between fundamental causes, such as education, and mortality. For example, the association between education and health may be attenuated in situations where the better educated are not able to fully utilize those resources (because of race, for example). From a public health perspective, understanding how different social and historical contexts are associated with health can help inform more targeted interventions.

Overall, previous evidence suggests that educational differentials in mortality are narrower in minorities; for example, in the US, education-mortality differentials [7-13] and health differentials [14] are greater in Whites than Blacks. Beyond this, one study found that for

Blacks the educational gradient was similar for both preventable and non-preventable causes of death; in contrast Whites had much larger education gradients among preventable causes of death [15]. This suggests that educational attainment in Blacks may not translate into health benefits in the same way it does for Whites [8]. The Hispanic Paradox, wherein Hispanics on average have better health and lower mortality compared to Whites of similar socioeconomic position has been well documented [10, 16-18], though the phenomenon appears to be disease specific [17]. One hypothesis for the paradox focuses on selection or the "healthy migrant" effect, where migrants are on average healthier than individuals who do not migrate. Another hypothesis is called the "salmon bias", in which older or ill immigrants go home to die, resulting in an undercount of their mortality statistics in the U.S. [19]. However, only a handful of studies using data from the US National Health Interview Study (NHIS) or vital statistics data have examined the Hispanic paradox in the context of educational attainment [4, 16, 20, 21]. Narrow education differentials among Hispanics may be due to remarkably low mortality and morbidity in low-educated Hispanics [4, 21], or differences in the educational distribution of migrants.

It is important to note the lack of in-depth analyses on the role of education on mortality in other minority groups in the U.S, particularly Asian Americans and Native Americans. Asians have much higher socioeconomic status (SES) than Blacks and Hispanics, suggesting they may have education-mortality differentials more similar to Whites. However, like Hispanics, Asians have much higher rates of immigration, a factor that is usually associated with narrower SES differentials. Moreover, there is some evidence that socioeconomic mortality differentials are narrower or non-existent in Japan compared to the U. S. [22] and may reverse in old ages, a fact that may be due to different social structure and patterns of

survivorship compared to Western countries [23-25]. Conversely, educational mortality differentials have been shown to be greater in Korea than many European countries [26].

The present analysis explores these questions using a novel dataset, which has a large sample size representative of the racial composition of the United States, the National Longitudinal Mortality Study (NLMS). The primary aim is to test whether the association between educational attainment and mortality is modified by race/ethnicity on either the multiplicative or additive scale or both. This line of research has important public health implications. First, it explicitly recognizes contingent factors, such as the lived experience of different racial groups in the United States, may modify the relationship between educational attainment and health outcomes. This framework is more realistic than simply asking whether education is a cause of better health, as it is doubtful that the association between educational attainment and mortality is unaffected by the different life course exposures. Relatedly, looking at variation in the association between educational attainment and health may lead to a greater understanding of the most salient pathways that lead the poorly educated to experience premature mortality.

Proposed Methods

Sample

Sponsored by the US National Institutes of Health, the National Center for Health Statistics, and the U.S. Census Bureau, the National Longitudinal Mortality Study (NLMS) was designed to study mortality differentials in demographic and socioeconomic groups [27]. The public use dataset is a random sample of the non-institutionalized population of the U.S. and

consists of 30 cohorts in all. Baseline data were obtained from the Annual Social and Economic Supplements which cover the period from March 1973 to March 2002; Current Population Surveys (CPS) for February 1978, April 1980, August 1980, December 1980, and September 1985; and one 1980 Census cohort. CPS respondents were matched using probabilistic methods based on personal identifiers to National Death Index data, which is maintained by the National Center for Health Statistics. Matching of CPS data to death data has been found to be largely effective at capturing all deaths in each study cohort [28]. Data related to mortality, such as cause of death, was also collected from death certificates.

To maintain confidentiality of participants, the timing of baseline interviews was not disclosed, and April 1, 1983 has been denoted as the starting point for all records. The weights are adjusted to reflect the U.S. population on that date. All socioeconomic and demographic data was self-reported and collected one time only, with no follow up, with the exception of mortality data, which was tracked up to 11 years following the interview. The public-use data file for the study currently includes data on 1,222,344 persons with more than 112,375 identified mortality records [29]. Respondents below age 25 were excluded from this analysis because educational attainment may not be completed before this age.

Outcome

The outcome measure in this analysis was all-cause mortality determined via death certificate data throughout 11 years of follow up from baseline.

Covariates

Educational attainment was measured in years at the time of interview. For lower levels, education was categorized as none; 1, 2, 3, or 4; 5 or 6; and 7 or 8. For those with at least 9 years of education, a single year was assigned up to 18 years of schooling. Before 1991, the CPS, the data source for educational attainment in NLMS, employed a years of schooling approach and switched to a degree achieved approach in 1992. The education variable in NLMS attempts to translate post-1991 data, which measures highest degree earned, into equivalent years of school to maintain consistency. This analysis classifies education into four mutually exclusive categories: less than high school (less than 12 years), high school only (exactly 12 years), some college (13-15 years), and Bachelor's degree or higher (16+ years).

Self-reported race and ethnicity were also collected in the CPS as White, Black, American Indian or Eskimo, Asian or Pacific Islander, and other, nonwhite. Hispanic origin was recorded as Mexican, other Hispanic, or non-Hispanic. In this analysis, racial categories were mutually exclusive; all Hispanics were classified as Hispanic, regardless of race chosen. Those of other race were excluded due to limited number of participants. Gender and immigration status were also self-reported and collected via CPS records.

Potential confounders and mediators of the association between education and mortality where included in the analysis. Age at time of interview (top coded at 90) was collected via CPS records. Urban versus rural status was determined via the 1970, 1980, or 1990 Census. An urban area consists of all places of 2,500 or more inhabitants. Marital status was classified as single, married, divorced/separated, or widowed). Family income was measured as percent of poverty level in 1990. Immigration status was coded as either born in the United States or not. Finally employment status (defined as employed; employed but absent from

work; unemployed; disabled, unable to work; and not in labor force because retired, student, homemaker, or other reason).

Statistical analysis

Descriptive statistics for the analytical sample were stratified by educational attainment (defined as high school and greater or less than high school) and mortality status over follow-up. Cox Proportional Hazard models were used to estimate the relative hazard of mortality. The proportional hazard assumption was not met for all covariates, but because the present dataset's large sample size will produce many significant results for even small deviations from the proportionality assumption, Schoenfeld residuals were also plotted and examined, and it was determined the proportionality assumption was reasonable. Hazard ratios for education was compared across each race (White as reference group) in three nested models: the first adjusted for age and sex, the second adjusted for age, sex, and immigration status, and the third adjusted for income as percent poverty level marital status, urbanicity, workforce status, and immigration status. Multiplicative interaction was assessed via an interaction term. Additive interaction was assessed via a method for hazard models developed by Li and Chambless [30]. Briefly this method allows us to assess additive interaction in Cox proportional hazards by calculating relative excess risk due to interaction (RERI) for each race-educational attainment combination. The general equation for RERI is as follows:

Let $p_{ij} = P(D=1 \mid G=i, E=j)$

$(p11 - p00) - [(p10 - p00) + (p01 - p00)] = p11 - p10 - p01 + p00$

Where G=Race category and E=Educaitonal attainment level

A RERI of 0 indicates no interaction. A RERI greater than 0 indicates superadditivity or positive interaction, while a RERI below 0 indicates subadditivity or negative interaction.

Proposed statistical analysis: To further assess additivity, we will attempt to fit additional mortality models such as Gompertz and Weibull.

Preliminary Results

The final analytic sample included 725,373 participants with a total of 2,718,457,891 days of follow up. Full descriptive characteristics of the sample are shown in Table 1. The study included 604,344 Non-Hispanic Whites, 61,019 Non-Hispanic Blacks, 42,910 Hispanics, 12,106 Non-Hispanic Asians, and 4,994 Non-Hispanic Native Americans. Those with more education were more likely to be male, non-Hispanic White, and urban ($P < 0.001$). Slightly more decedents were male (Table 1).

Asians had the lowest hazard of death (HR: 0.62, 95% CI: 0.49, 0.77), followed by Hispanics ($P < 0.001$). Native Americans had the same hazard of mortality as Whites (HR: 1.00, 95% CI: 0.58, 1.71). Higher educational attainment was associated with lower hazards of mortality for all groups. Multiplicative interaction terms for race/ethnicity were not significant in most cases. However, our preliminary analysis suggests additive interaction may be present for some racial groups at some educational attainment levels.

Preliminary Discussion

The aim of this study was to examine the relationship between mortality and educational attainment in the US in understudied races/ethnicities. We found that educational attainment was associated with lower mortality, consistent with a wide body of literature [1,

10, 16, 31-36]. There are several reasons why the relationship between education and health may differ by race/ethnicity [15], such as the fact quality of schooling varies among groups, discrimination in the labor market [7, 37-39], and contextual contingency, or competing demands on time such as incarceration or burdensome caregiving roles may be more acute for some races [40, 41]. The educational distribution of each group may also play a role. For example, Whites are the highest educated racial group (Ryan & Bauman, 2016); it is reasonable to assume that those unable to obtain a high school diploma may be more severely disadvantaged than their educational counterparts in racial categories where educational attainment is generally lower, such as Native Americans.

While in the present analysis multiplicative interaction effects show no evidence of interactions between race and education, additive models may provide a different perspective on the absolute mortality differences for major US race/ethnic groups. We will fully explore both the differences in methodology between multiplicative and additive interaction effects as well as their interpretation and importance to public health. Previous research on the interaction between sociodemographic variables and health and mortality has almost exclusively focused on multiplicative effects. However fully understanding the nature of interactions among risk factors can provide greater insight into the complex relationships that can ultimately lead to mortality [42].

A few limitations should be noted. Educational attainment was obtained only once at baseline, and could have changed over time. Moreover, it is possible that certain racial or ethnic groups may differentially obtain a degree later in life. Additionally, several important confounding variables were not measured, such as childhood health and other socioeconomic

variables. In addition, selection bias due to mortality may affect results because cohorts that reach the oldest ages may be compositionally different than their peers who failed to live to advanced ages [23-25].

Future research should examine how the causal pathways may differ in the relationships between demographic characteristics, socioeconomic status, and mortality across time and place.

Table 1 Descriptive characteristics of the National Longitudinal Mortality Study by education level.

		Educational attainment			
	Overall	< HS	HS	SC	College
	(%)	(%)	(%)	(%)	(%)
Race					
Non-Hispanic white	82.98%	73.12%	85.86%	85.44%	89.48%
Non-Hispanic Black	10.21%	16.06%	8.93%	8.97%	5.24%
Hispanic	4.97%	9.08%	3.79%	3.84%	2.33%
Asian	1.44%	1.13%	1.04%	1.34%	2.80%
American Indian or	0.40%	0.60%	0.38%	0.41%	0.15%
Sex					
Female	46.84%	53.60%	57.90%	52.32%	43.56%
Male	53.16%	46.40%	42.10%	47.68%	56.44%
Immigration status					
Immigrant	6.48%	8.69%	4.90%	5.63%	7.22%
Native born	93.52%	91.31%	95.10%	94.37%	92.78%
Death status					
Alive	85.60%	73.08%	88.86%	90.85%	92.79%
Not alive	14.40%	26.92%	11.14%	9.15%	7.21%
Age at time of interview					
25-34	27.86%	13.41%	29.87%	37.70%	36.47%
35-44	20.98%	13.33%	22.24%	24.31%	26.75%
45-54	16.75%	16.42%	18.19%	14.88%	15.93%
55-64	15.81%	20.64%	16.30%	11.88%	11.11%
65-74	11.75%	20.89%	9.57%	7.46%	6.49%
75-84	5.57%	12.23%	3.23%	3.14%	2.70%
85+	1.27%	3.08%	0.59%	0.64%	0.54%
Urbanity					
Rural	29.97%	34.09%	32.26%	25.77%	22.84%
Urban	70.03%	65.91%	67.74%	74.23%	77.16%
Income as percent of poverty level					
Above poverty level	88.29%	75.13%	91.14%	93.80%	97.05%
At or less than poverty level	12.00%	24.87%	8.86%	6.20%	2.95%

Table 2. Hazard of death by educational attainment and race/ ethnicity in the National Longitudinal Mortality Study.

	Model 1 (Adjusted age and sex)				**Model 2 (Adjusted for age, sex, and immigration status)**				**Model 3 (full covariates)***			
	HR	**95% CI lower**	**95% CI upper**	**p value**	**HR**	**95% CI lower**	**95% CI upper**	**p value**	**HR**	**95% CI lower**	**95% CI upper**	**p value**
Education												
Less than high school	1.62	1.58	1.67	**<0.001 ***	1.62	1.58	1.67	**<0.001 ***	1.53	1.49	1.57	**<0.001 ***
High school only	1.36	1.33	1.40	**<0.001 ***	1.36	1.32	1.40	**<0.001 ***	1.34	1.30	1.38	**<0.001 ***
Some college	1.26	1.22	1.30	**<0.001 ***	1.25	1.21	1.29	**<0.001 ***	1.24	1.20	1.28	**<0.001 ***
College	ref	ref	ref	ref	ref	ref	Ref	ref	ref	ref	ref	ref
Race												
Non-Hispanic Black	1.38	1.23	1.54	**<0.001 ***	1.38	1.23	1.54	**<0.001 ***	1.32	1.18	1.48	**<0.001 ***
Hispanic	0.77	0.64	0.92	**0.005 ***	0.88	0.73	1.06	0.181	0.87	0.73	1.05	0.152
Asian	0.62	0.49	0.77	**<0.001 ***	0.75	0.60	0.94	**0.013 ***	0.75	0.60	0.94	**0.014 ***
American Indian or Eskimo	1.00	0.58	1.71	0.991	0.99	0.58	1.71	0.983	0.95	0.56	1.62	0.85
Non-Hispanic White	ref	ref	ref	ref	ref	ref	Ref	ref	ref	ref	ref	ref
* Adjusted for age, sex, income as percent of poverty level, marital status, urbanicity, workforce status, and immigration status												

Table 3. Age and sex adjusted hazard of death for pairs of race/ethnicity and educational combinations in the National Longitudinal Mortality Study.

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Risk Factor Pairs	**HR: (yes/yes)**	**95% CI Upper**	**Lower**	**RERI**	**P-value: Additive interaction**	**P-value: Multiplicative interaction**
Less than high school-black	1.92	1.85	1.99	0.215	**<0.0001 ***	**0.001 ***
High school-black	1.98	1.87	2.10	0.166	**<0.0001 ***	0.986
Some college-black	1.81	1.65	1.99	0.049	0.133	0.825
Less than high school-Hispanic	1.27	1.21	1.33	0.085	**0.005 ***	0.413
High school-Hispanic	1.18	1.08	1.30	0.069	0.075	0.633
Some college-Hispanic	1.00	0.85	1.16	0.075	**0.043 ***	0.845
Less than high school-Asian	1.02	0.90	1.17	0.103	**0.020 ***	0.514
High school-Asian	0.88	0.75	1.02	0.132	**0.036 ***	0.604
Some college-Asian	0.88	0.67	1.17	0.100	**0.022 ***	0.756
Less than high school-Native American	1.66	1.45	1.89	0.165	0.065	0.943
High school-Native American	1.65	1.27	2.15	0.165	0.150	0.49
Some college-Native American	1.48	0.95	2.33	0.126	0.265	0.645
College-white	Ref	ref	ref	ref	ref	ref

Note: Hazard ratio (HR) pertains to the presence of both risk factors (yes/yes). Additive interaction assessed in unweighted models.

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